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PATENT SPECIFICATION

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(19)

(72) Inventors HORST BEYER and HANS-JÜRGEN VEUTGEN

(54) WEAR-RESISTANT CAST-IRON ALLOY

(71) We, GOETZEWERKE FRIEDRICH GOETZE AKTIENGESELLSCHAFT, a Body Corporate organised and existing under the laws of the Federal Republic of Germany, of Bürgermeister-Schmidt-Strasse 17, 5763 Burscheid, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a wear-resistant cast iron alloy suitable for the construction of machine parts subject to high frictional stresses.

Machine elements subjected to friction are strongly stressed both with regard to wear and thermally, so that particularly high demands have to be made on their materials. Certain machine elements, such as the piston rings of internal combustion engines and the sealing strips of rotary piston engines, are furthermore subjected to particularly heavy stresses. Experience has shown that only very expensive materials of complicated manufacture withstand such high stresses. Usually, these materials are sintered metal carbides, to which very specific alloying elements have been added.

The sorts of cast iron so far tested, however, cannot be used for these highly stressed machine parts. It is known that the wear resistance of cast iron can be increased by the addition of alloying elements. On solidification of the cast iron, however, these elements form relatively coarse grains and very hard carbides, which then cause damage, accompanied by scoring, to the contacting surfaces. At the same time, carbide formation uses up the greater part of the carbon, so that these alloys do not contain in their structure the necessary graphite for emergency running of machine elements. Furthermore, these materials are so brittle that they are unable to withstand mechanical stresses and therefore break.

In accordance with the present invention there is provided a wear-resistant cast iron alloy, suitable for the construction of machine parts subject to high frictional stresses, the alloy containing

1.5 to 4.0% by weight of carbon
1.5 to 6.0% by weight of silicon
less than 0.2% by weight of sulphur
less than 2.5% by weight of phosphorus
1.0 to 7.0% by weight of copper
0.4 to 3.2% by weight of nickel and/or cobalt
0.1 to 1.8% by weight of tin and/or antimony
0.1 to 4.0% by weight of molybdenum
0.1 to 4.0% by weight of tungsten
0.05 to 2.5% by weight of manganese

0.3 to 2.5% by weight of chromium
0.3 to 4.0% by weight of vanadium
0 to 2.0% by weight of titanium
0.1 to 4.0% by weight of niobium and/or tantalum
0.1 to 2.0% by weight of aluminium

and the rest iron except for atmospheric nitrogen combined with the metals as a result of melting and heat treatment.

The cast iron alloys in accordance with the invention display uncombined carbon as lamellar and primarily nodular precipitates. There are also present however a large number of carbides in a very fine crystalline precipitated form.

The sum of the elements carbon and silicon in the alloys in accordance with the invention is equal to or greater than 3% by weight and the ratio of silicon to carbon is preferably equal to or greater than one. The sum of the elements molybdenum, tungsten and manganese should preferably be between 0.2 and 10% while the sum of the elements chromium, vanadium, tantalum and niobium should preferably be between 1 and 10%.

In addition, it has been found that for refining the form of the individual structural constituents, more particularly that of the graphite, and the nitrides (when present), the elements boron, bismuth, zirconium, magnesium and/or the rare-earth metals may be added. Their total concentration should not, however, exceed the value of 0.5 percent by weight.

By heat treatment above 700°C, followed by quenching for example in air or a salt bath to a temperature of below 500°C, and subsequent tempering up to a temperature of 700°C, wear resistance and compatibility with the counter-material are greatly increased.

The alloys according to the invention have a bainitic to martensitic basic structure. The graphite precipitates are lamellar to nodular, the carbide precipitates are punctiform to spherical. The hardness of this material at HV 5 lies at 550 to 920 kg/mm². The material is not brittle and cast sealing strips for rotary piston engines are wear resistance and in test runs exhibit very good wear resistance with the trochoidal surface of the rotary piston engine.

The embodiment example describes one of the cast-iron alloys according to the invention. The cast-iron melt comprises the elements

2.2% by weight carbon
3.9% by weight silicon
0.9% by weight phosphorus
0.08% by weight sulphur
1.4% by weight copper
0.6% by weight nickel
0.2% by weight tin
1.5% by weight molybdenum
3.4% by weight tungsten
0.9% by weight manganese
0.4% by weight chromium
1.5% by weight vanadium
0.2% by weight titanium
0.7% by weight niobium
0.01% by weight boron
0.22% by weight aluminium

and the rest iron.

After inoculation with one of the usual inoculants, sealing strips for rotary piston engines were cast from the melt using the sand mould casting process, the dimensions of the strips being 61.03×8.3×4.95 mm. They were then annealed for one hour at 850°C, quenched in an oil bath at room temperature and tempered for one hour at 350°C.

The sealing strips thus made had an HV 5 hardness of 644 to 713 kg/mm². In test runs, the sealing strips showed very good wear resistance, while the trochoidal running surfaces were only slightly affected.

Figures 1 to 4 show photomicrographs of the cast-iron alloy of the example.

Figure 1 is the unetched specimen at a magnification of ×100, showing the graphite in lamellar to nodular form.

Figure 2 is the unetched specimen at a magnification of ×500, showing in addition to the dark graphite precipitates, the finely crystalline carbide constituents as light areas with a dark edge.

Figure 3 shows a specimen etched with HNO_3 at a magnification of ×500 which shows, in addition to the graphite precipitates and the crystalline carbide constituents, the bainitic to martensitic structure.

Figure 4 shows the phosphide eutectic, deeply etched, at a magnification of ×20.

WHAT WE CLAIM IS:—

1. A wear resistant cast iron alloy, suitable for the construction of machine parts subject to high frictional stresses, the alloy containing

1.5 to 4.0% by weight of carbon
1.5 to 6.0% by weight of silicon
less than 0.2% by weight of sulphur
less than 2.5% by weight of phosphorus
1.0 to 7.0% by weight of copper
0.4 to 3.2% by weight of nickel and/or cobalt
0.1 to 1.8% by weight of tin and/or antimony
0.1 to 4.0% by weight of molybdenum
0.1 to 4.0% by weight of tungsten
0.05 to 2.5% by weight of manganese
0.3 to 2.5% by weight of chromium
0.3 to 4.0% by weight of vanadium
0 to 2.0% by weight of titanium
0.1 to 4.0% by weight of niobium and/or tantalum
0.1 to 2.0% by weight of aluminium

and the rest iron except for atmospheric nitrogen combined with the metals as a result of melting and heat treatment.

2. An alloy as claimed in Claim 1 modified by the addition of up to 0.5% by weight in total of one or more of the elements boron, bismuth, magnesium, zirconium and rare earth metals.

3. An alloy as claimed in Claim 1 or 2 which has been subjected to heat treatment by annealing above 700°C, quenching to below 500°C and then tempering up to a temperature of 700°C.

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FIG. 1

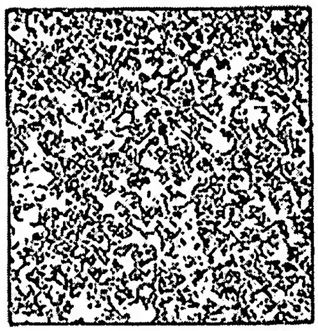

FIG. 2

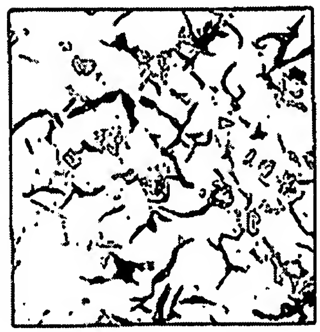

FIG. 3

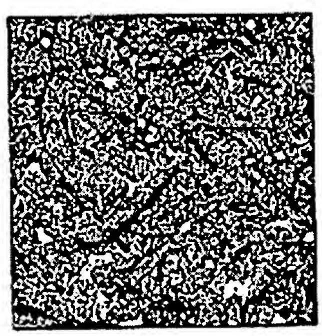

FIG. 4